

Study of Preoperative Dexmedetomidine Vs Fentanyl on Hemodynamic Response to Laryngoscopy and Tracheal Intubation

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Received: 01-07-2026 / Revised: 15-08-2026 / Accepted: 21-09-2026

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Conflict of interest: Nil

Abstract

Background: Laryngoscopy and tracheal intubation are associated with transient sympathetic stimulation resulting in increases in heart rate and arterial blood pressure. Attenuation of this haemodynamic response is desirable to reduce cardiovascular stress during airway manipulation. Dexmedetomidine, an α_2 -adrenergic agonist with sympatholytic properties, may provide more effective haemodynamic control than opioids such as fentanyl. The present study compared intravenous dexmedetomidine and fentanyl for attenuation of the haemodynamic response to laryngoscopy and tracheal intubation.

Methods: This prospective, randomized, comparative study was conducted in 50 patients belonging to ASA physical status I or II, aged 20–60 years, scheduled for elective surgery under general anaesthesia. Patients were randomly allocated into two groups of 25 each. Group D received dexmedetomidine 1 $\mu\text{g/kg}$ and Group F received fentanyl 2 $\mu\text{g/kg}$, with both drugs diluted in 20 mL normal saline and administered intravenously over 10 minutes before induction. Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation were monitored. Haemodynamic parameters were recorded before induction, at induction, after induction, immediately after intubation, and at 1, 2, 3, 4, 5, 10, and 15 minutes after intubation.

Results: The demographic characteristics of the two groups were comparable. Both dexmedetomidine and fentanyl attenuated the haemodynamic response associated with laryngoscopy and tracheal intubation. Heart rate was significantly lower in the dexmedetomidine group at multiple time points from after induction through 10 minutes after intubation, while the groups were comparable at 15 minutes. Systolic blood pressure showed significantly better attenuation with dexmedetomidine at post-intubation and selected subsequent time points. Diastolic blood pressure was significantly lower in the dexmedetomidine group during several measurements between 1 and 5 minutes after intubation. Mean arterial pressure also demonstrated significantly better attenuation with dexmedetomidine at post-intubation and several early post-intubation intervals. No patient required rescue medication or repetition of the study drug. One patient developed hypotension and two developed bradycardia in the dexmedetomidine group after the predefined 15-minute observation period; these events were managed without serious complications.

Conclusion: Both dexmedetomidine 1 $\mu\text{g/kg}$ and fentanyl 2 $\mu\text{g/kg}$ administered intravenously over 10 minutes before induction were effective in attenuating the haemodynamic response to laryngoscopy and tracheal intubation. Dexmedetomidine provided more consistent and superior haemodynamic stability than fentanyl, particularly during the early post-intubation period, with no significant serious adverse effects observed during the study period.

Keywords: Dexmedetomidine, Fentanyl, Laryngoscopy, Tracheal intubation.

DOI: 10.25258/ijcpr.18.10.25

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Introduction

Laryngoscopy and tracheal intubation are essential components of general anaesthesia and are associated with a characteristic transient cardiovascular response. Mechanical stimulation of

the laryngeal and tracheal structures activates the sympathetic and sympathoadrenal systems, resulting in increases in heart rate and arterial blood pressure. This response was first described in detail

by Reid and Brace and subsequently characterized by King and colleagues. Although these changes are generally short-lived and well tolerated by healthy individuals, they may become clinically significant in patients with cardiovascular, cerebrovascular, or other systemic comorbidities. [1,2] The magnitude of the haemodynamic response depends on several factors, including the depth of anaesthesia, duration and force of laryngoscopy, technique of airway manipulation, and the pharmacological agents used during induction. An exaggerated sympathetic response may result in tachycardia, hypertension, increased myocardial oxygen demand, myocardial ischaemia, arrhythmias, heart failure, or cerebrovascular complications in susceptible individuals. Therefore, attenuation of the pressor response remains an important objective of modern anaesthetic practice. [3,4]

Several pharmacological approaches have been investigated to reduce the cardiovascular response associated with laryngoscopy and tracheal intubation. These include intravenous and topical lignocaine, opioids, β -adrenergic blockers, vasodilators, calcium-channel blockers, magnesium, and α 2-adrenergic agonists. However, no single technique has been universally accepted as ideal because the efficacy, duration of action, and adverse-effect profile vary among different agents. [3,4]

Fentanyl is a potent synthetic opioid that has been widely used during induction of general anaesthesia. By activating μ -opioid receptors and reducing sympathetic outflow and catecholamine release, fentanyl can attenuate the cardiovascular response to airway manipulation. Its rapid onset and relatively short duration of action make it a commonly used agent for blunting the haemodynamic response associated with laryngoscopy and intubation. [5]

Dexmedetomidine is a highly selective α 2-adrenergic receptor agonist with sympatholytic, sedative, and analgesic properties. Its ability to reduce sympathetic activity makes it particularly useful for controlling haemodynamic responses during stressful perioperative events. Dexmedetomidine has also been associated with reduced requirements for other anaesthetic and analgesic agents. However, its use may be accompanied by adverse effects such as bradycardia and hypotension, particularly with higher doses or rapid administration. [6]

Several clinical studies have demonstrated the potential role of dexmedetomidine in attenuating the haemodynamic response to laryngoscopy and tracheal intubation. Yildiz et al. reported that dexmedetomidine reduced perioperative haemodynamic responses and anaesthetic

requirements during laryngoscopy and intubation. [7] Similar findings have been reported in patients undergoing major surgery, supporting the sympatholytic effect of dexmedetomidine during airway manipulation. [8] Comparative studies have also suggested that dexmedetomidine may provide greater haemodynamic stability than conventional opioid-based approaches in selected patients. Bajwa et al. demonstrated attenuation of the pressor response and reduction in opioid and anaesthetic requirements with preoperative dexmedetomidine. [9] Gunalan et al. also reported better attenuation of the haemodynamic response with dexmedetomidine compared with fentanyl when administered before laryngoscopy and tracheal intubation. [10]

Despite these findings, differences in drug dose, timing of administration, anaesthetic technique, patient characteristics, and methods of haemodynamic assessment make direct comparison between studies difficult. A clinically relevant comparison of dexmedetomidine and fentanyl using standardized doses and consistent monitoring of heart rate and blood pressure is therefore useful. The present study was undertaken to compare intravenous dexmedetomidine and fentanyl administered before induction of general anaesthesia for attenuation of the haemodynamic response to laryngoscopy and tracheal intubation.

Methodology

This was a prospective, randomized, comparative experimental study conducted in the Department of Anaesthesiology at SAL Hospital and Medical Institute, Ahmedabad, from October 2020 to May 2021. The study was conducted after obtaining approval from the Institutional Ethics Committee, and written informed consent was obtained from all patients before enrolment.

A total of 50 patients scheduled for elective surgery under general anaesthesia were included in the study. Patients were randomly allocated using a computer-generated randomization method into two equal groups of 25 patients each. Group D consisted of 25 patients who received dexmedetomidine, while Group F consisted of 25 patients who received fentanyl.

The sample size was calculated using the standard formula for estimating sample size based on the standard normal variate, standard deviation, and permissible margin of error. The calculated sample size was 60.21. After considering a 15% allowance for dropouts, the final sample size was taken as 50 patients, with 25 patients included in each study group.

Patients aged 20–60 years, belonging to ASA physical status I or II, of either sex, and scheduled for elective surgery under general anaesthesia were included. Patients belonging to ASA physical status

III or IV, patients refusing participation, and those with associated psychiatric or neurological illness, thyroid dysfunction, hypertension, uncontrolled diabetes mellitus, cerebrovascular disease, ischaemic heart disease, cardiac arrhythmias, chronic obstructive pulmonary disease, history of allergic reaction, pregnancy, lactation, or electrolyte imbalance were excluded. Patients with an anticipated difficult airway were also excluded. Patients requiring prolonged laryngoscopy of more than 30 seconds or a second attempt at tracheal intubation were excluded from the study.

A detailed pre-anaesthetic assessment was performed one day before surgery, including history, physical examination, systemic examination, and relevant investigations. All patients were kept fasting for 8 hours before surgery. After shifting to the operating room, intravenous access was established and Ringer lactate infusion was started. Baseline pulse rate, blood pressure, electrocardiogram, and oxygen saturation were recorded. Glycopyrrolate was administered as premedication 15 minutes before induction.

Patients in Group D received dexmedetomidine 1 µg/kg diluted in 20 mL normal saline, while patients in Group F received fentanyl 2 µg/kg diluted in 20 mL normal saline. The respective study drug was administered intravenously over 10 minutes before induction of anaesthesia.

Following preoxygenation for 3 minutes, general anaesthesia was induced with propofol administered in intermittent doses until loss of eyelash reflex and response to verbal commands. Suxamethonium chloride was subsequently administered for neuromuscular blockade. After approximately 90 seconds, direct laryngoscopy and tracheal intubation were performed using a standard Macintosh laryngoscope and an appropriately sized cuffed endotracheal tube. Intubation was performed by an experienced anaesthesiologist.

Only a single successful intubation attempt completed within the predefined time was accepted for the study. Bilateral equal air entry was confirmed following intubation, after which the endotracheal tube was fixed and mechanical ventilation was initiated. Following recovery from suxamethonium, atracurium bromide was administered for neuromuscular blockade and maintained intermittently during surgery. Anaesthesia was maintained with an inhalational anaesthetic agent along with oxygen and air.

The principal haemodynamic parameters assessed were heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure. Oxygen saturation and electrocardiographic monitoring

were also performed throughout the perioperative period. Haemodynamic parameters were recorded at predefined intervals: before induction, at induction, after induction, and after laryngoscopy at 1, 2, 3, 4, 5, 10, and 15 minutes. The changes in heart rate and blood pressure following laryngoscopy and tracheal intubation were compared between the dexmedetomidine and fentanyl groups. The study also assessed the occurrence of adverse effects in both groups, the requirement for rescue medication or repetition of the study drug, and whether the attenuation of the haemodynamic response was influenced by the person performing the intubation.

At the end of surgery, residual neuromuscular blockade was antagonized using neostigmine and glycopyrrolate. Extubation was performed after the patient fulfilled the criteria for routine awake extubation. Patients were subsequently shifted to the recovery area and monitored for perioperative complications, including pain, nausea, vomiting, muscle rigidity, and respiratory complications.

Data were analysed using SPSS version 20 for Windows. Appropriate statistical tests, including the chi-square test, Student's t-test, and proportion test, were used according to the type and distribution of the variables. Continuous variables including pulse rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation were expressed as mean $\pm$ standard deviation. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1 shows the demographic characteristics of the two study groups. Both groups consisted of 25 patients each. The mean age was 46.56 ± 10.759 years in Group D and 46.08 ± 13.282 years in Group F, indicating comparable age distribution between the groups. The age range was 26–60 years in Group D and 21–60 years in Group F. The mean BMI was 21.80 ± 1.414 kg/m² in Group D and 22.04 ± 1.274 kg/m² in Group F. In Group D, 11 patients (44%) were female and 14 (56%) were male, whereas Group F comprised 7 females (28%) and 18 males (72%). Overall, the demographic characteristics were comparable between the two groups.

Table 2 demonstrates the comparison of heart rate between Group D and Group F at different peri-intubation intervals. The baseline heart rate was comparable between the groups. Following induction and laryngoscopy, Group F showed an increase in heart rate, whereas Group D demonstrated a progressive reduction in heart rate. The difference between the groups became statistically significant after induction and remained significant from post-intubation through

10 minutes after intubation. The most pronounced difference was observed at 4 minutes, when the mean heart rate was 68.36 beats/min in Group D compared with 78.72 beats/min in Group F ($p < 0.001$). At 15 minutes, the heart rate values were comparable between the groups, with no statistically significant difference.

Table 3 shows the comparison of systolic blood pressure. The baseline and pre-intubation values were comparable between the two groups. Following laryngoscopy and tracheal intubation, systolic blood pressure increased in both groups, but the increase was greater in Group F.

A statistically significant difference was observed immediately after intubation, at 1 minute, and at 4 minutes. The mean systolic blood pressure immediately after intubation was 124 mmHg in Group D compared with 131 mmHg in Group F ($p = 0.002$). At 1 minute, the corresponding values were 111 mmHg and 121 mmHg, respectively ($p = 0.002$). The values subsequently approached baseline levels, and no statistically significant difference was observed at 15 minutes.

Table 4 presents the comparison of diastolic blood pressure between the two groups. Baseline diastolic blood pressure was comparable between Group D

and Group F. Following laryngoscopy and intubation, an increase was observed in both groups; however, the rise was attenuated more effectively in Group D. Statistically significant differences were observed from 1 to 5 minutes after intubation. At 3 minutes, the mean diastolic blood pressure was 73 mmHg in Group D compared with 80 mmHg in Group F ($p < 0.001$). Similar statistically significant differences were observed at 1, 2, 4, and 5 minutes. By 10 and 15 minutes, the values between the two groups were no longer statistically different.

Table 5 demonstrates the comparison of mean arterial pressure between Group D and Group F. The baseline and pre-intubation values were comparable. Following laryngoscopy and tracheal intubation, Group F showed a greater increase in mean arterial pressure, whereas Group D demonstrated better attenuation of the haemodynamic response. Statistically significant differences were observed immediately after intubation and at 2, 3, 4, 5, and 10 minutes. At 3 minutes, the mean arterial pressure was 73 mmHg in Group D compared with 80 mmHg in Group F ($p < 0.001$). The difference was no longer statistically significant at 15 minutes, when the values were 76 mmHg and 77 mmHg, respectively.

Table 1: Demographic Characteristics of Study Participants

Variable	Group D (n=25)	Group F (n=25)
Age (years), Mean $\pm$ SD	46.56 $\pm$ 10.759	46.08 $\pm$ 13.282
Minimum age (years)	26	21
Maximum age (years)	60	60
BMI (kg/m ²), Mean $\pm$ SD	21.80 $\pm$ 1.414	22.04 $\pm$ 1.274
Female, n (%)	11 (44.0)	7 (28.0)
Male, n (%)	14 (56.0)	18 (72.0)

Table 2: Comparison of Heart Rate at Different Time Intervals

Time interval	Group D	Group F	p-value
Before induction	75.96	77.72	0.243
At induction	73.28	75.28	0.154
After induction	76.44	80.08	0.006
Post-intubation	76.36	79.32	0.030
1 min	75.68	79.64	0.014
2 min	69.88	77.08	<0.001
3 min	70.60	79.72	<0.001
4 min	68.36	78.72	<0.001
5 min	70.04	75.24	0.002
10 min	70.56	76.52	<0.001
15 min	72.48	75.40	0.110

Table 3: Comparison of Systolic Blood Pressure at Different Time Intervals

Time interval	Group D (mmHg)	Group F (mmHg)	p-value
Before induction	124	123	0.40
At induction	119	118	0.63
After induction	126	125	0.67
Post-intubation	124	131	0.002
1 min	111	121	0.002
2 min	110	115	0.08
3 min	116	120	0.90
4 min	113	119	0.02
5 min	114	118	0.31
10 min	119	121	0.42
15 min	115	118	0.28

Table 4: Comparison of Diastolic Blood Pressure at Different Time Intervals

Time interval	Group D (mmHg)	Group F (mmHg)	p-value
Before induction	80	79	0.70
At induction	74	75	0.58
After induction	83	83	0.66
Post-intubation	80	82	0.13
1 min	75	81	0.001
2 min	73	77	0.004
3 min	73	80	<0.001
4 min	74	79	<0.001
5 min	74	79	<0.001
10 min	75	77	0.45
15 min	76	77	0.66

Table 5: Comparison of Mean Arterial Pressure at Different Time Intervals

Time interval	Group D (mmHg)	Group F (mmHg)	p-value
Before induction	80	79	0.74
At induction	75	75	0.97
After induction	83	83	0.54
Post-intubation	80	82	0.005
1 min	75	81	0.235
2 min	73	77	0.001
3 min	73	80	<0.001
4 min	74	79	0.001
5 min	74	79	0.001
10 min	75	77	<0.001
15 min	76	77	0.27

Discussion

Laryngoscopy and tracheal intubation are important components of general anaesthesia but are associated with a transient sympathoadrenal response that can produce changes in heart rate and arterial blood pressure.

In the present study, both dexmedetomidine and fentanyl demonstrated an attenuating effect on the haemodynamic response; however, the magnitude and consistency of attenuation were greater with dexmedetomidine. This finding supports the role of pharmacological premedication in minimizing cardiovascular responses associated with airway manipulation. Parida et al. also demonstrated that pharmacological agents can effectively modify the

haemodynamic response to tracheal intubation, although their study evaluated fentanyl and gabapentin-based regimens rather than dexmedetomidine. [11]

The demographic characteristics of the present study population were comparable between the two groups. The mean age and BMI were similar in the dexmedetomidine and fentanyl groups, and there was no clinically important difference in the distribution of male and female participants. Comparable baseline characteristics are important in a randomized comparative study because they reduce the possibility that differences in haemodynamic responses are attributable to demographic variation rather than to the intervention. Shin et al. similarly evaluated

dexmedetomidine as a preanaesthetic adjunct in patients undergoing general anaesthesia and demonstrated its usefulness as part of a standardized anaesthetic technique. [12]

In the present study, heart rate demonstrated a clear difference between the two treatment groups following induction and airway manipulation. The mean heart rate in the dexmedetomidine group remained lower than that in the fentanyl group at several subsequent time points, with statistically significant differences observed from the post-induction period through 10 minutes after intubation. By 15 minutes, the difference was no longer statistically significant. This indicates that dexmedetomidine produced a more sustained attenuation of the chronotropic response associated with laryngoscopy and tracheal intubation. The findings are in agreement with the comparative observations reported by Mahiswar et al., who found dexmedetomidine to be more effective than fentanyl in controlling the stress response to laryngoscopy and intubation. [13]

The greater control of heart rate observed with dexmedetomidine may be attributed to its sympatholytic effect. Unlike fentanyl, which attenuates the sympathetic response primarily through opioid-mediated reduction of sympathetic outflow, dexmedetomidine produces a more pronounced sympatholytic effect through α_2 -adrenergic receptor activity. In the present study, the dexmedetomidine group did not demonstrate the relative tachycardic response observed with fentanyl after airway manipulation. The findings are consistent with studies evaluating dexmedetomidine as an agent for attenuation of the haemodynamic response to intubation. [14]

Systolic blood pressure also demonstrated better attenuation with dexmedetomidine. Although the groups were comparable before induction, at induction, and after induction, a significant difference was observed post-intubation and at selected subsequent time points. The systolic blood pressure in the fentanyl group was relatively higher following intubation, whereas the dexmedetomidine group demonstrated greater haemodynamic stability. This suggests that dexmedetomidine was more effective in controlling the pressor component of the response to laryngoscopy and tracheal intubation. Similar beneficial effects of dexmedetomidine on haemodynamic responses have been reported with preoperative administration of the drug. [15]

A similar pattern was observed for diastolic blood pressure. The two groups showed comparable values during the pre-induction, induction, and post-induction periods, whereas significantly lower values were observed in the dexmedetomidine group at several early post-intubation time points.

The differences were particularly evident from 1 to 5 minutes after intubation, after which the groups became comparable. These findings indicate that the effect of dexmedetomidine was most pronounced during the immediate and early period following airway manipulation, which is the period when sympathetic stimulation is expected to be greatest. Comparative studies evaluating dexmedetomidine and other pharmacological agents have similarly demonstrated its ability to attenuate the haemodynamic response associated with laryngoscopy and intubation. [11,14] Mean arterial pressure findings further supported the superiority of dexmedetomidine. The baseline and induction values were comparable between the two groups, whereas significant differences were observed after intubation and at several subsequent intervals. The greatest differences were observed during the early post-intubation period, while the values became comparable at 15 minutes. The pattern observed for mean arterial pressure was consistent with the findings for systolic and diastolic blood pressure and therefore provides additional evidence that dexmedetomidine produced more effective attenuation of the overall pressor response. The haemodynamic effects observed in the present study are comparable with the beneficial effects described in previous studies of dexmedetomidine used before airway instrumentation. [12]

An additional observation in the present study was that the volume of propofol required to achieve loss of eyelash reflex and response to verbal commands appeared to be lower in the dexmedetomidine group than in the fentanyl group. This observation suggests a possible anaesthetic-sparing effect of dexmedetomidine. However, because the present study did not specifically quantify propofol consumption as a primary outcome, this finding should be interpreted as an observation rather than as definitive evidence of a propofol-sparing effect. Similar anaesthetic-sparing properties have been described with preoperative dexmedetomidine administration. [12,13]

No patient in either group required rescue medication or repetition of the study drug because of an excessive haemodynamic response. There was no clinically significant sudden rise in heart rate or blood pressure requiring additional intervention during the predefined observation period. Furthermore, intubations were performed by experienced anaesthesiologists, and no meaningful variation in haemodynamic response attributable to the individual performing intubation was observed. These findings suggest that, under standardized airway and anaesthetic conditions, both agents were effective in preventing an excessive cardiovascular response, with

dexmedetomidine providing greater consistency. [13,14]

Regarding safety, the present study demonstrated only limited adverse haemodynamic effects with dexmedetomidine. One patient developed hypotension and two patients developed bradycardia; importantly, these events occurred after the predefined 15-minute study observation period. The hypotension was managed by reducing the concentration of the inhalational anaesthetic and administering intravenous fluids, while the bradycardia and hypotension were appropriately managed without further complications. No adverse effects were noted in the fentanyl group. These observations are relevant because bradycardia and hypotension are recognized haemodynamic effects that may occur with dexmedetomidine, particularly because of its sympatholytic action. Previous studies evaluating dexmedetomidine for attenuation of airway-related haemodynamic responses have also emphasized its efficacy together with the need for appropriate monitoring of its cardiovascular effects. [15]

The overall findings of the present study indicate that both dexmedetomidine 1 µg/kg and fentanyl 2 µg/kg administered intravenously over 10 minutes before induction were effective in attenuating the haemodynamic response to laryngoscopy and tracheal intubation.

However, dexmedetomidine demonstrated a more consistent reduction in heart rate and better attenuation of systolic blood pressure, diastolic blood pressure, and mean arterial pressure during the early post-intubation period. The results are in agreement with comparative evidence showing favourable haemodynamic effects of dexmedetomidine in the setting of airway manipulation. [11-15]

The present study has certain limitations. The sample size was relatively small, with 25 patients in each group, and the study population consisted only of ASA physical status I and II patients undergoing elective surgery. Therefore, the findings may not be directly generalizable to patients with significant cardiovascular disease or other high-risk conditions. In addition, plasma catecholamine concentrations were not measured; hence, the assessment of sympathetic attenuation was based primarily on clinical haemodynamic parameters. Larger studies involving high-risk populations and objective biochemical markers of sympathetic activation may provide further evidence regarding the comparative efficacy of dexmedetomidine and fentanyl. [11-15]

Conclusion

Both intravenous dexmedetomidine at a dose of 1 µg/kg and fentanyl at a dose of 2 µg/kg,

administered over 10 minutes before induction of general anaesthesia, were effective in attenuating the haemodynamic response to laryngoscopy and tracheal intubation. However, dexmedetomidine provided superior and more consistent haemodynamic control compared with fentanyl, particularly with respect to heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure during the early post-intubation period. The dexmedetomidine group demonstrated greater haemodynamic stability without the need for rescue medication or repetition of the study drug.

Although bradycardia and hypotension were observed in a small number of patients receiving dexmedetomidine, these events occurred after the predefined study observation period and were managed without serious complications. Therefore, dexmedetomidine 1 µg/kg administered intravenously over 10 minutes before induction may be considered an effective and clinically useful option for attenuating the haemodynamic response to laryngoscopy and tracheal intubation.

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